Complete Summary

GUIDELINE TITLE

Acute chest pain—suspected pulmonary embolism.

BIBLIOGRAPHIC SOURCE(S)

Bettmann MA, Lyders EM, Yucel EK, Khan A, Haramati LB, Ho VB, Rozenshtein A, Rybicki FJ, Schoepf UJ, Stanford W, Woodard PK, Jaff M, Expert Panel on Cardiac Imaging. Acute chest pain--suspected pulmonary embolism. [online publication]. Reston (VA): American College of Radiology (ACR); 2006. 5 p. [42 references]

GUIDELINE STATUS

This is the current release of the guideline.

This guideline updates a previous version: Bettmann MA, Boxt LM, Gomes AS, Grollman J, Henkin RE, Higgins CB, Kelley MJ, Needleman L, Pagan-Marin H, Polak JF, Stanford W, Ashburn W. Acute chest pain--suspected pulmonary embolism. American College of Radiology. ACR Appropriateness Criteria. Radiology 2000 Jun;215(Suppl):15-21.

The appropriateness criteria are reviewed annually and updated by the panels as needed, depending on introduction of new and highly significant scientific evidence.

COMPLETE SUMMARY CONTENT

SCOPE

DISEASE/CONDITION(S)

Acute chest pain, suspected pulmonary embolism

GUIDELINE CATEGORY

Diagnosis

CLINICAL SPECIALTY

Cardiology
Emergency Medicine
Family Practice
Internal Medicine
Radiology

INTENDED USERS

Health Plans
Hospitals
Managed Care Organizations
Physicians
Utilization Management

GUIDELINE OBJECTIVE(S)

To evaluate the appropriateness of initial radiologic examinations for patients with acute chest pain, suspected pulmonary embolism

TARGET POPULATION

Patients with acute chest pain, suspected pulmonary embolism

INTERVENTIONS AND PRACTICES CONSIDERED

1. X-ray, chest
2. Computed tomography angiography (CTA), chest
    - Multidetector CT (MDCT)
    - With CT venography
3. Ultrasound (US)
    - Duplex Doppler, lower extremities
    - Echocardiography, transesophageal (TEE)
    - Echocardiography, transthoracic (TTE)
4. Nuclear medicine, ventilation/perfusion (V/Q) scan
5. Invasive (INV), pulmonary angiography with right heart catheterization
6. Magnetic resonance angiography (MRA), chest

MAJOR OUTCOMES CONSIDERED

Utility of radiologic examinations in differential diagnosis

METHODOLOGY

METHODS USED TO COLLECT/SELECT EVIDENCE

Searches of Electronic Databases

DESCRIPTION OF METHODS USED TO COLLECT/SELECT THE EVIDENCE

The guideline developer performed literature searches of peer-reviewed medical journals and the major applicable articles were identified and collected.

NUMBER OF SOURCE DOCUMENTS

The total number of source documents identified as the result of the literature search is not known.

METHODS USED TO ASSESS THE QUALITY AND STRENGTH OF THE EVIDENCE

Weighting According to a Rating Scheme (Scheme Not Given)

RATING SCHEME FOR THE STRENGTH OF THE EVIDENCE

Not stated

METHODS USED TO ANALYZE THE EVIDENCE

Systematic Review with Evidence Tables

DESCRIPTION OF THE METHODS USED TO ANALYZE THE EVIDENCE

One or two topic leaders within a panel assume the responsibility of developing an evidence table for each clinical condition, based on analysis of the current literature. These tables serve as a basis for developing a narrative specific to each clinical condition.

METHODS USED TO FORMULATE THE RECOMMENDATIONS

Expert Consensus (Delphi)

DESCRIPTION OF METHODS USED TO FORMULATE THE RECOMMENDATIONS

Since data available from existing scientific studies are usually insufficient for meta-analysis, broad-based consensus techniques are needed for reaching agreement in the formulation of the appropriateness criteria. The American College of Radiology (ACR) Appropriateness Criteria panels use a modified Delphi technique to arrive at consensus. Serial surveys are conducted by distributing questionnaires to consolidate expert opinions within each panel. These questionnaires are distributed to the participants along with the evidence table and narrative as developed by the topic leader(s). Questionnaires are completed by participants in their own professional setting without influence of the other members. Voting is conducted using a scoring system from 1-9, indicating the least to the most appropriate imaging examination or therapeutic procedure. The

survey results are collected, tabulated in anonymous fashion, and redistributed after each round. A maximum of three rounds is conducted and opinions are unified to the highest degree possible. Eighty percent agreement is considered a consensus. This modified Delphi technique enables individual, unbiased expression, is economical, easy to understand, and relatively simple to conduct.

If consensus cannot be reached by the Delphi technique, the panel is convened and group consensus techniques are utilized. The strengths and weaknesses of each test or procedure are discussed and consensus reached whenever possible. If "No consensus" appears in the rating column, reasons for this decision are added to the comment sections.

RATING SCHEME FOR THE STRENGTH OF THE RECOMMENDATIONS

Not applicable

COST ANALYSIS

The guideline developers reviewed published cost analyses.

METHOD OF GUIDELINE VALIDATION

Internal Peer Review

DESCRIPTION OF METHOD OF GUIDELINE VALIDATION

Criteria developed by the Expert Panels are reviewed by the American College of Radiology (ACR) Committee on Appropriateness Criteria.

RECOMMENDATIONS

MAJOR RECOMMENDATIONS

ACR Appropriateness Criteria®

Clinical Condition: Acute Chest Pain–Suspected Pulmonary Embolism

Radiologic Procedure	Appropriateness Rating	Comments
X-ray, chest	9	To exclude other causes of acute chest pain
CTA, chest, multidetector (MDCT)	9	Current standard of care for detection of PE
CTA, chest, with CT venography	7	If suspicion for DVT is high and/or if US inconclusive
US, lower extremities,	7	If chest x-ray is negative and index of

Radiologic Procedure	Appropriateness Rating	Comments
duplex Doppler		suspicion is high
NM, V/Q scan	6	If chest x-ray is negative and CTA is contraindicated or nondiagnostic.
INV, pulmonary angiography with right heart catheterization	5	If suspicion is high and CTA is inconclusive
MRA, chest	4	If patient is unable to receive iodinated contrast, may be alternative to V/Q scan.
US, echocardiography, transesophageal (TEE)	2	Limited experience. Has been used for main pulmonary emboli.
US, echocardiography, transthoracic (TTE)	2	To assess right ventricle function after the diagnosis of PE
Appropriateness Criteria Scale **1 2 3 4 5 6 7 8 9** **1 = Least appropriate 9 = Most appropriate**		

Abbreviations

- CT, computed tomography
- CTA, computed tomography angiography
- DVT, deep vein thrombosis
- INV, invasive
- MDCT, multidetector computed tomography
- MRA, magnetic resonance angiography
- NM, nuclear medicine
- PE, pulmonary embolism
- TEE, transesophageal
- TTE, transthoracic
- US, ultrasound
- V/Q, ventilation/perfusion

Summary of Literature Review

Over 200,000 cases of pulmonary thromboembolism (PE) are estimated to occur in the United States each year. Additional cases may not be diagnosed because the symptoms of chest pain, shortness of breath, tachycardia, etc, are nonspecific and may mimic other pulmonary or cardiac conditions. Unsuspected PE continues to be a frequent autopsy finding.

It has been further estimated that over 80% of PE cases are associated with deep vein thrombosis (DVT). It is, therefore, easy to see why pulmonary embolism, for purposes of both diagnosis and treatment, is often considered a complication or a

consequence of DVT. The only concern with this approach is that there is not invariably an association: some cases of PE are due to embolization from other sites, such as pelvic veins or the upper extremities, or even from the right heart or from in situ thrombosis.

Diagnostic efforts in radiology are aimed at: (1) reaching an acceptable level of diagnostic certainty of pulmonary embolism (PE) to warrant anticoagulant therapy, using the least invasive tests, and (2) eliminating other reasons for the patient's symptoms. Over the past decade, the probability of a patient having PE is typically arrived at using a Bayesian approach in which the pre-test likelihood of the condition (PE), based on clinical and laboratory evidence, is then modified by the results of the appropriate radiological procedure(s) in order to estimate a post-test probability of the condition. This approach has changed over the last five years, largely due to technological advances and clinical studies using multidetector computed tomography (CT), in combination with studies such as serum D-dimer.

Plain Chest Radiograph

The posterior/anterior and lateral chest radiograph is an important initial study because it may eliminate the need for additional radiographic procedures by revealing an obvious reason for acute symptoms, such as pneumonia. A recent chest radiograph is particularly useful, even required, if an abnormal pattern is identified on radionuclide perfusion lung scan. The chest radiograph findings may help clarify confusing scan patterns.

Computed Tomography

Computed tomography pulmonary angiography (CTPA) is indicated in the evaluation of patients suspected of having a pulmonary embolism. CTPA has been playing an increasingly significant role in the diagnosis of pulmonary embolism since the first major clinical study in 1992. Technological advancements in CT, from helical CT to the use of multidetector CT, have led to better resolution of the pulmonary tree, and numerous studies have examined the accuracy of CTPA as compared to ventilation/perfusion (V/Q) imaging and conventional angiography. There appears to be an evolving consensus that CTA is now the primary imaging modality to evaluate patients suspected of having acute PE.

Multiple studies have shown that CTPA is highly sensitive and specific; discrepancies with conventional angiography are mainly at the subsegmental level where even angiographers tend to have poorer inter-observer agreement. Intra- and inter-observer variability for CTPA have been shown to be very good to the segmental level, better than with V/Q imaging. Overall, CTPA has been shown to have a higher sensitivity and specificity than V/Q scans.

When combined with clinical assessment and serum D-dimer, the results of CTA can be highly predictive. A positive CTA result combined with high or intermediate suspicion on clinical assessment has a high positive predictive value. In patients with low clinical suspicion and a negative CTA, acute PE can safely be ruled out. In addition, the adjunctive use of CT venography with CTA improves the sensitivity of the detecting deep vein thrombosis (DVT), with similar specificity.

CTPA also has fewer "nondiagnostic" studies than V/Q scans. Studies have shown it to be a useful adjunct to V/Q imaging in certain clinical situations and, more recently, as a primary screening exam. Initial outcome studies have shown no adverse outcomes in patients with a negative CTA who were not subsequently treated. Another study has shown CTPA to be cost-effective in conjunction with lower extremity duplex exams. More recently, as noted, the combination of multidetector CTA (MDCTA) and high-specificity D-dimer assay has been shown to have very high positive and negative predictive values. In addition, CTPA may occasionally demonstrate pathology other than PE that may be responsible for the patient's symptoms.

Conventional CT with contrast material is generally not indicated in the routine work-up of acute chest pain thought to be secondary to acute PE. Some clinical evidence, however, suggests that high contrast CT may be useful in assessing patients with pulmonary hypertension thought to be secondary to chronic, recurrent pulmonary embolism.

A few studies have suggested that electron beam CT may be useful to evaluate for PE, but it is not widely available and evidence supporting its role is limited. In general, data support the use of MDCTA as more accurate than single slice CT or other studies, such as V/Q scans.

Ventilation and Perfusion Imaging

Since its introduction in the mid-1960s, lung perfusion imaging has been considered to be indicated in the workup of patients with suspected PE. The role of lung perfusion imaging for evaluating suspected PE has, however, diminished with the widespread use of CTA. Still, a totally normal pattern of regional perfusion in multiple projections accompanied by a normal ventilation scan, is widely accepted as indicating that pulmonary emboli are not present and no further work-up (for PE) is necessary.

An abnormal pattern of regional perfusion (Q) may be suggestive, but is not specific, for the diagnosing PE, and thus requires correlation with other modalities such as ventilation (V) imaging and a recent chest radiograph. These are performed to help differentiate between reduced pulmonary arterial blood flow due to vascular obstructions and secondary reductions in regional blood flow associated with a variety of airways diseases.

A "mismatched" V/Q pattern consisting of both abnormal perfusion and normal ventilation in the same region (e.g., segments) may strongly point to the presence of vascular obstruction(s). However, this pattern is not specific to PE, because other conditions may also reduce pulmonary arterial blood flow while preserving ventilation in the same region (e.g., malignancies, arthritis).

In most cases a "matched" V/Q pattern (defects) suggests the presence of airways disease, thus lowering the probability of PE. Even so, it is often difficult to evaluate scans in which widespread ventilatory abnormalities are known to exist, e.g., chronic obstructive pulmonary disease (COPD), and/or when extensive abnormalities are observed in more than 50% of one or both lungs on the chest radiograph.

A number of schemes based on various V/Q scan patterns have been developed to assign different probabilities for the presence (or absence) of PE. Many of these use somewhat different (confusing to some) criteria. Generally, V/Q findings are categorized as: "high probability" (mismatched V/Q defects), "intermediate probability" (essentially not meeting the criterion of either "high" or "low"), "low probability" (matched V/Q defects), and "normal" (no perfusion defects). All of the probability schemes incorporate the results of a recent plain chest radiograph. At least one study suggests that using single pattern emission computed tomography (SPECT) imaging improves the sensitivity and specificity of V/Q scintigraphy.

Ventilation imaging may be performed either before or after macroaggregated albumin (MAA) perfusion imaging. Performing a (low- dose) MAA scan before the Xe-133 V scan has the advantage of allowing the V scan to be obtained in the appropriate projection, rather than in the usual posterior projection. Results with technetium -99m (Tc-99m)-labeled microaerosol agents (DTPA, pertechnetate, etc.) are comparable to studies using inert gases such as xenon or krypton and have the advantage of providing multiple views for regional V/Q comparisons.

Lung scans sometimes may be indicated in pregnant women, in which case the administered dose of the radiopharmaceutical(s) should be reduced by a factor of three or more with correspondingly longer acquisition times to achieve adequate imaging statistics. In this way, radiation-absorbed dose may be minimized. If the MMA Q scan is performed first and is normal, the V imaging can be avoided.

A follow-up MAA Q scan may be recommended 6–8 weeks after the discovery of a "mismatched" V/Q pattern (presumption of PE), because failure of observed resolution or at least significant improvement in regional perfusion may signal the ultimate development (less than 1%) of pulmonary hypertension secondary to chronic thromboembolic obstruction in the major pulmonary vessels. Caution should be exercised in interpreting perfusion imaging soon (days) after acute PE, because reestablishment of regional perfusion (resolution of defects) occurs at varying and unpredictable rates.

MAA Perfusion Imaging without Ventilation Imaging

MMA perfusion (Q) imaging alone, without ventilation, may be indicated particularly when the condition of the patient suddenly deteriorates and acute PE is suspected as a significant contributory cause. The demonstration of regions of reduced perfusion, not explained by recent plain radiograph findings, warrants a consideration of PE and possibly the need for further work-up such as pulmonary angiography. It may also be indicated in patients who are not candidates for MDCTA, such as those who are too large for available CT gantries or who are unable to remain still and breath-hold for even the few seconds necessary.

Selective Pulmonary Angiography

Pulmonary angiography, including right heart catheterization and measurement of pulmonary artery and right heart pressures, is an acceptably safe, albeit invasive, procedure when performed in a facility that ensures adequate monitoring of patients. The results may establish the specific diagnosis of PE when an acceptable level of certainty cannot be reached by noninvasive imaging. However, the experience of the radiologist who performs and interprets this invasive

procedure is crucial. As noted, studies suggest that the overall accuracy of catheter pulmonary angiography may be inferior to that of MDCTA, due to technical factors such as patient movement and vessel overlap, as well as inter- and intra-observer variability in interpretation.

The amount of contrast material injected should be limited to that necessary to establish (or exclude) the presence of PE. The number of selective arterial injections may be reduced by evaluating suspicious pulmonary vascular territories indicated by the results of noninvasive V/Q lung scanning. Magnification techniques and imaging in special projection may overcome problems with overlapping vessels.

The general indications for pulmonary angiography in the past included a) cases with "low" or "intermediate" probability V/Q scan findings, particularly when there is a high clinical suspicion for PE, but anticoagulation is considered risky or contraindicated; b) circumstances where a specific diagnosis (i.e., PE) is considered necessary for the proper management of the patient; c) when pulmonary thromboendarterectomy is considered (e.g., chronic pulmonary hypertension secondary to major vessel thromboembolic occlusion), and d) before placement of an inferior vena cava (IVC) filter. With the recent technical advances with MDCTA and studies demonstrating its accuracy, there are now fewer cases in which catheter pulmonary angiography is indicated or necessary.

Ultrasound

Because of the high association of DVT and pulmonary embolism, ultrasound (US) evaluation of the venous drainage of the lower extremities is probably indicated. Abnormal US studies are not specific for acute DVT, as they may not indicate whether this is a relative new occurrence or a chronic condition. Obstruction of venous flow does not indicate the presence (or absence) of PE, but may increase (or decrease) its likelihood. Positive studies may identify patients at higher risk for subsequent PE. A negative study does not exclude PE.

Ultrasound studies include duplex Doppler with leg compression and continuous wave (CW) Doppler. For a more detailed discussion, refer to the Appropriateness Criteria® topic of deep vein thrombosis.

Transesophageal echo (TEE) and transthoracic echo (TTE) studies are generally not indicated in the workup of acute chest pain in the setting of suspected acute PE. These US procedures, however, may be helpful in evaluating right ventricular function in suspected chronic, major-vessel thromboembolic pulmonary hypertension, or in evaluating risk of right heart failure in patients with massive or submassive acute PE. While sonography may be a useful adjunct, it cannot exclude PE.

Magnetic Resonance Imaging/Angiography

Magnetic resonance imaging (MRI) is probably not indicated in the routine evaluation of patients with suspected PE. It may rarely be useful in patients who have large central emboli, particularly if used in conjunction with MRI for other indications, such as cardiac morphologic evaluation. Magnetic resonance angiography (MRA), while not as widely utilized, has many of the advantages of

MDCTA: it provides rapid, noninvasive evaluation of the central pulmonary arteries. Technologic innovations and increased experience may increase the role of MRA. Currently, it is mainly used in certain centers with particular interest and expertise, and in patients in whom contrast administration for MDCTA, or even for pulmonary angiography, is thought to be contraindicated because of renal failure, prior reaction to iodinated contrast, pulmonary hypertension or for other reasons.

Anticipated Exceptions

If MDCTA is not available, then V/Q scans, pulmonary MRA or lower extremity ultrasound may need to be used for evaluation.

CLINICAL ALGORITHM(S)

Algorithms were not developed from criteria guidelines.

EVIDENCE SUPPORTING THE RECOMMENDATIONS

TYPE OF EVIDENCE SUPPORTING THE RECOMMENDATIONS

The recommendations are based on analysis of the current literature and expert panel consensus.

BENEFITS/HARMS OF IMPLEMENTING THE GUIDELINE RECOMMENDATIONS

POTENTIAL BENEFITS

Selection of appropriate radiologic imaging procedures for evaluation of patients with acute chest pain, suspected pulmonary embolism

POTENTIAL HARMS

Not stated

QUALIFYING STATEMENTS

QUALIFYING STATEMENTS

An American College of Radiology (ACR) Committee on Appropriateness Criteria and its expert panels have developed criteria for determining appropriate imaging examinations for diagnosis and treatment of specified medical condition(s). These criteria are intended to guide radiologists, radiation oncologists, and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those exams generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate

imaging procedures or treatments. Imaging techniques classified as investigational by the U.S. Food and Drug Administration (FDA) have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.

IMPLEMENTATION OF THE GUIDELINE

DESCRIPTION OF IMPLEMENTATION STRATEGY

An implementation strategy was not provided.

IMPLEMENTATION TOOLS

Personal Digital Assistant (PDA) Downloads

For information about availability, see the "Availability of Companion Documents" and "Patient Resources" fields below.

INSTITUTE OF MEDICINE (IOM) NATIONAL HEALTHCARE QUALITY REPORT CATEGORIES

IOM CARE NEED

Getting Better

IOM DOMAIN

Effectiveness

IDENTIFYING INFORMATION AND AVAILABILITY

BIBLIOGRAPHIC SOURCE(S)

Bettmann MA, Lyders EM, Yucel EK, Khan A, Haramati LB, Ho VB, Rozenshtein A, Rybicki FJ, Schoepf UJ, Stanford W, Woodard PK, Jaff M, Expert Panel on Cardiac Imaging. Acute chest pain--suspected pulmonary embolism. [online publication]. Reston (VA): American College of Radiology (ACR); 2006. 5 p. [42 references]

ADAPTATION

Not applicable: The guideline was not adapted from another source.

DATE RELEASED

1995 (revised 2006)

GUIDELINE DEVELOPER(S)

American College of Radiology - Medical Specialty Society

SOURCE(S) OF FUNDING

The American College of Radiology (ACR) provided the funding and the resources for these ACR Appropriateness Criteria®.

GUIDELINE COMMITTEE

Committee on Appropriateness Criteria, Expert Panel on Cardiac Imaging

COMPOSITION OF GROUP THAT AUTHORED THE GUIDELINE

Panel Members: Michael A. Bettmann, MD; Eric M. Lyders, MD; E. Kent Yucel, MD; Arfa Khan, MD; Linda B. Haramati, MD; Vincent B. Ho, MD; Anna Rozenshtein, MD; Frank J. Rybicki, MD, PhD; U. Joseph Schoepf, MD; William Stanford, MD; Pamela K. Woodard, MD; Michael Jaff, MD

FINANCIAL DISCLOSURES/CONFLICTS OF INTEREST

Not stated

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The appropriateness criteria are reviewed annually and updated by the panels as needed, depending on introduction of new and highly significant scientific evidence.

GUIDELINE AVAILABILITY

Electronic copies: Available (in Portable Document Format [PDF]) from the American College of Radiology (ACR) Web site.

ACR Appropriateness Criteria® *Anytime*, *Anywhere*™ (PDA application). Available from the ACR Web site.

Print copies: Available from the American College of Radiology, 1891 Preston White Drive, Reston, VA 20191. Telephone: (703) 648-8900.

AVAILABILITY OF COMPANION DOCUMENTS

The following is available:

- ACR Appropriateness Criteria®. Background and development. Reston (VA): American College of Radiology; 2 p. Electronic copies: Available in Portable Document Format (PDF) from the American College of Radiology (ACR) Web site.

PATIENT RESOURCES

None available

NGC STATUS

This summary was completed by ECRI on February 20, 2001. The information was verified by the guideline developer on March 14, 2001. This summary was updated by ECRI Institute on April 25, 2007.

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